

How the Thermosphere Shapes the Quiet-Time Plasmasphere

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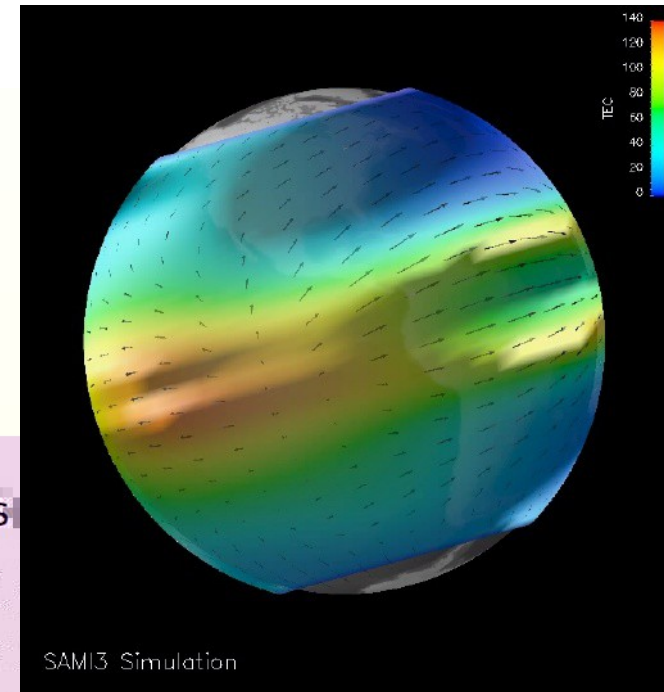
[2]ASTRA, LLC.

GEM 2014 Living With a Star Science Meeting
November 6, 2014

Supported by the Naval Research Laboratory Base Program and NASA LWS

SAMI3: The NRL Ionosphere/Plasmasphere Model

- Magnetic field: ~~IGRF-like~~ non-tilted dipole
- Interhemispheric
- Nonorthogonal, nonuniform fixed grid
- Seven (7) ion species (**all ions are equal**):
 H^+ , He^+ , N^+ , O^+ , N_2^+ , NO^+ , and O_2^+
 - Solve continuity and momentum for all 7 species
 - Solve temperature for H^+ , He^+ , O^+ , and e^-
- Plasma motion
 - $E \times B$ drift perpendicular to B
 - **Ion inertia included parallel to B**
- Neutral species: NRLMSISE00 and HWM93
- Chemistry: 21 reactions + recombination
- Photoionization: Daytime (EUVAC) and nighttime



We use the Weimer 2005 model for the magnetospheric potential.

SAMI3: ion dynamics and winds

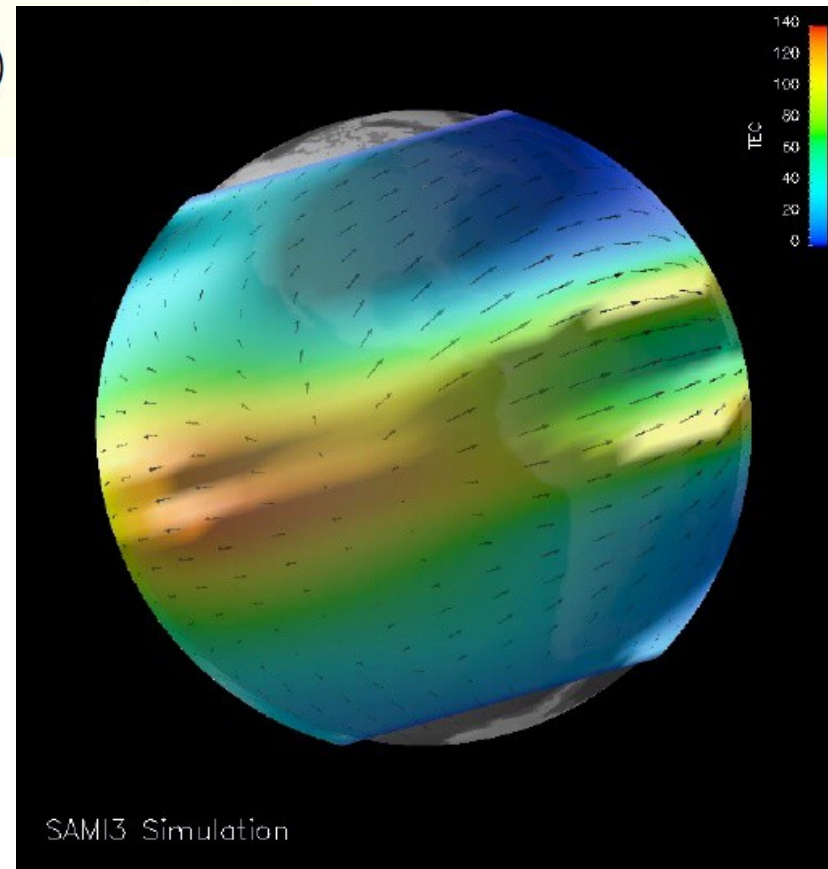
Direct force:

$$\frac{\partial \mathbf{V}_i}{\partial t} + \mathbf{V}_i \cdot \nabla \mathbf{V}_i = -\frac{1}{\rho_i} \nabla \mathbf{P}_i + \frac{e}{m_i} \mathbf{E} + \frac{e}{m_i c} \mathbf{V}_i \times \mathbf{B} + \mathbf{g} - \nu_{in}(\mathbf{V}_i - \mathbf{V}_n) - \sum_j \nu_{ij}(\mathbf{V}_i - \mathbf{V}_j)$$

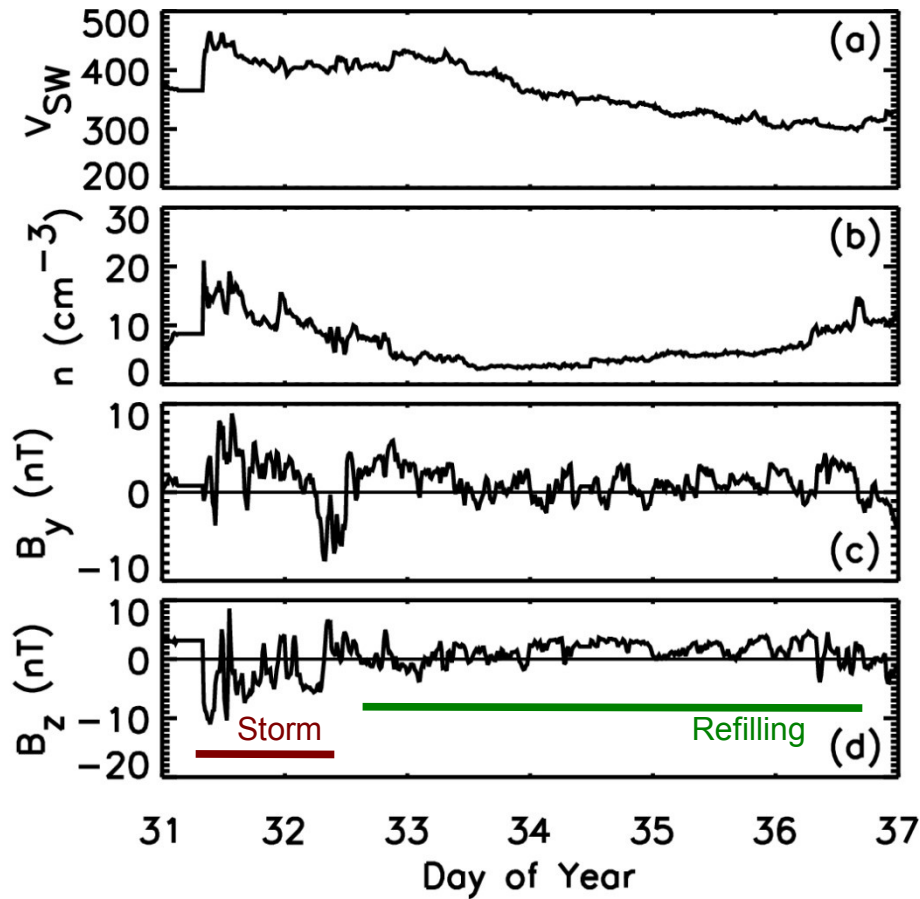
Wind-driven dynamo:

$$\nabla \cdot \Sigma \nabla \Phi = S(g, \mathbf{V}_n, J_{\parallel})$$

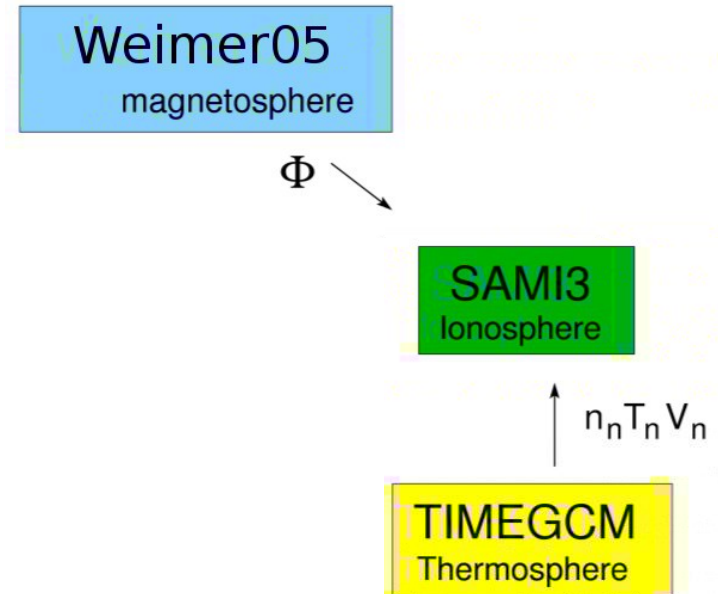
$$\mathbf{E} = -\nabla \Phi$$



2001 Day 32-36: a quiet period after a storm

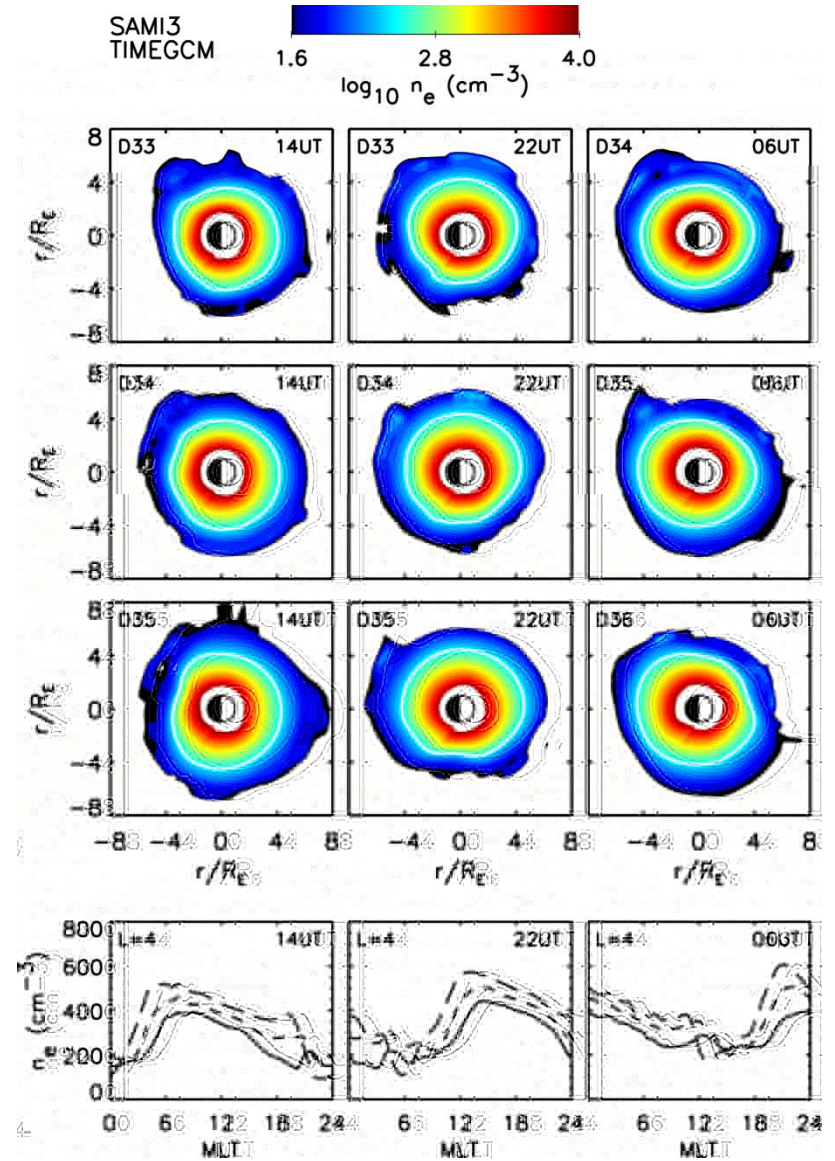
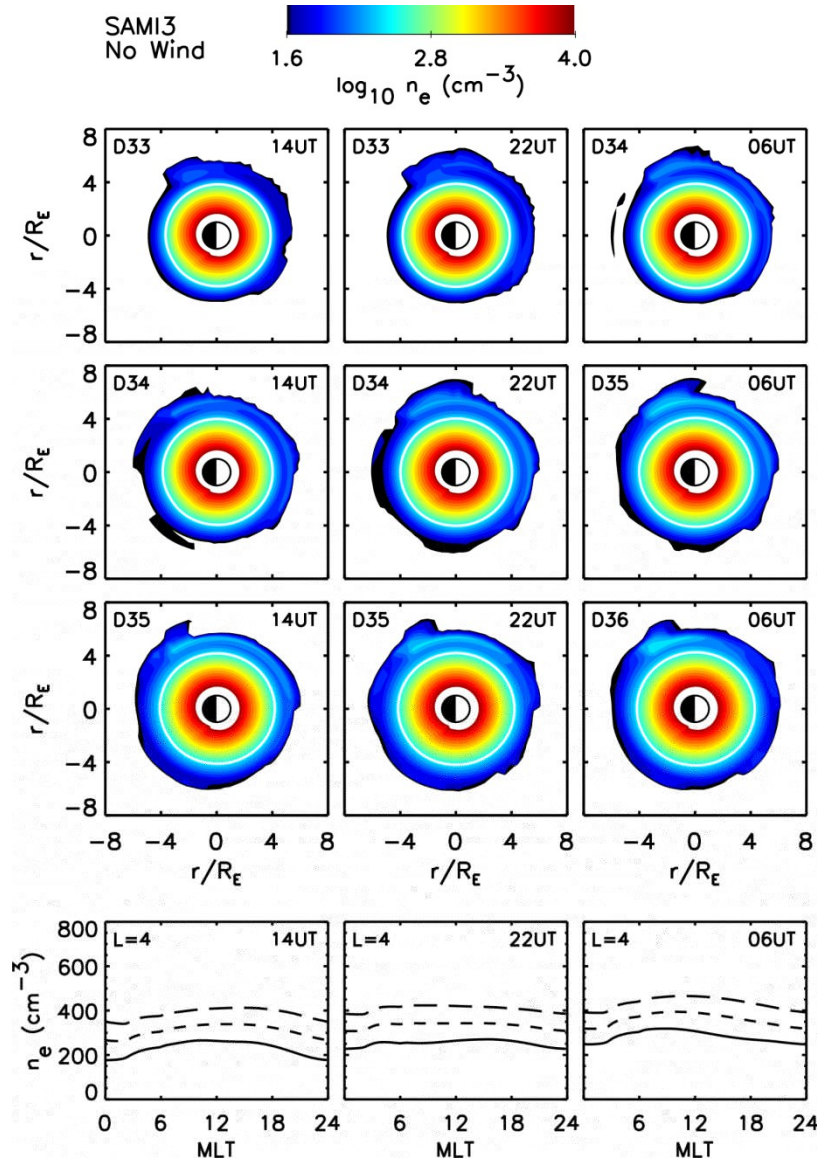


SAMI3/Weimer 7-day run:
1 quiet day (day 30)
2 storm days
4 refilling days (day 33-36)

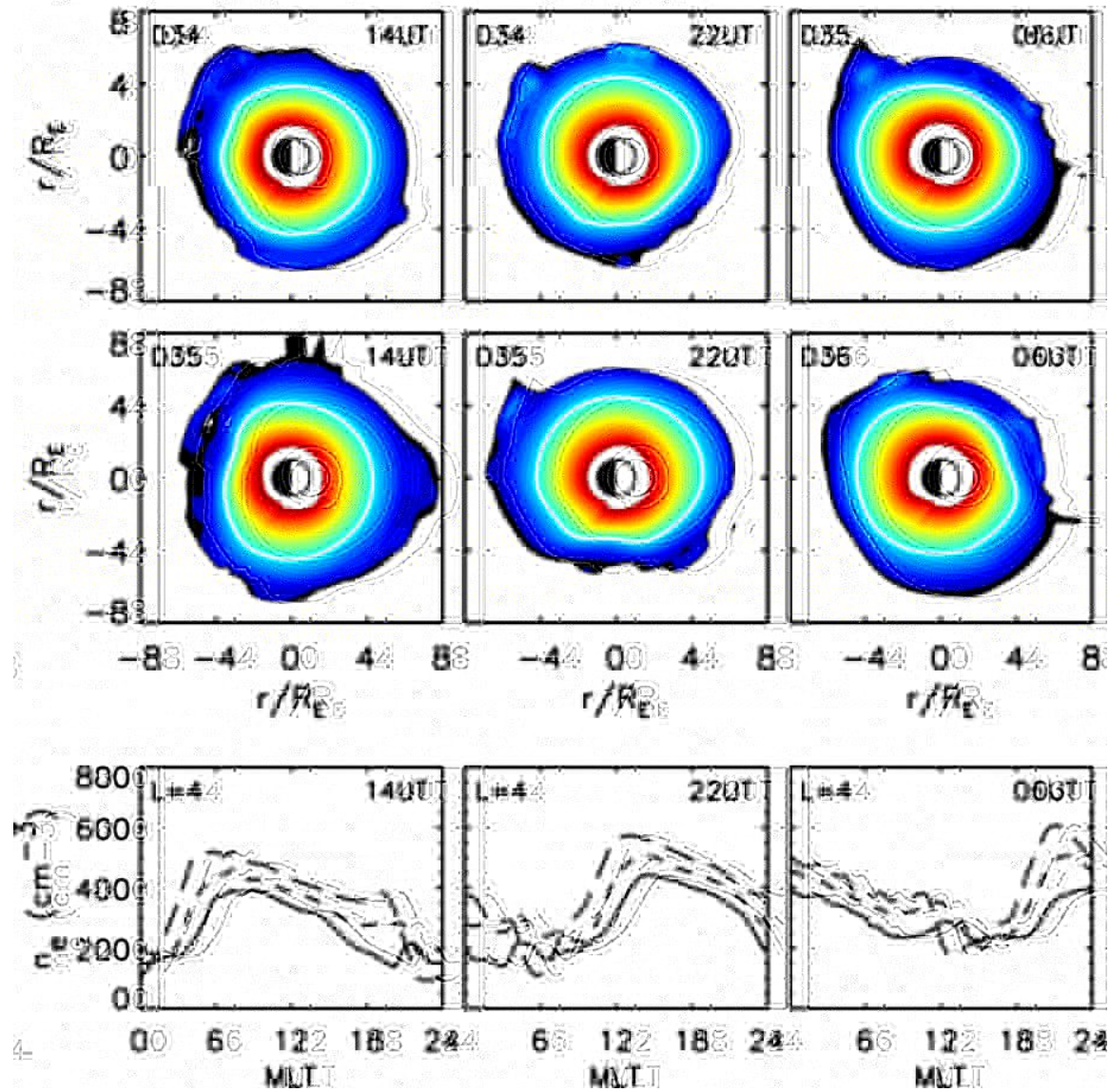


Data from CDAWeb/OMNI

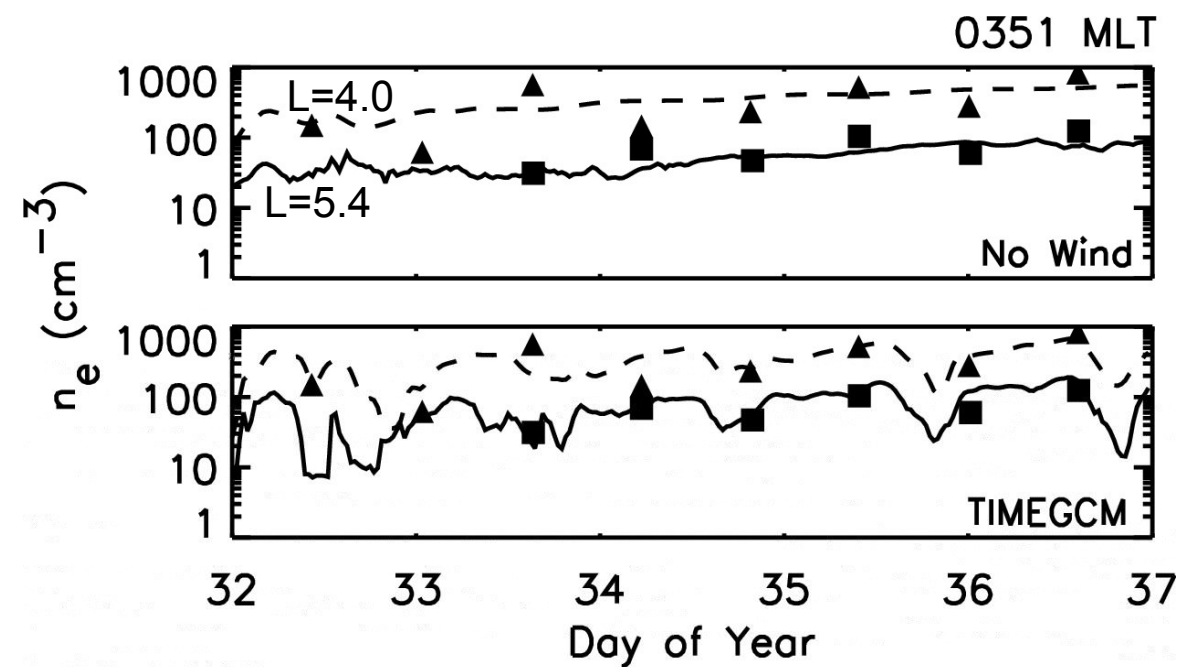
2001 Day 32-36: SAMI3 with no winds and with TIMEGCM



2001 Day 32-36: SAMI3/TIMEGCM



2001 Day 32-36: IMAGE RPI electron density



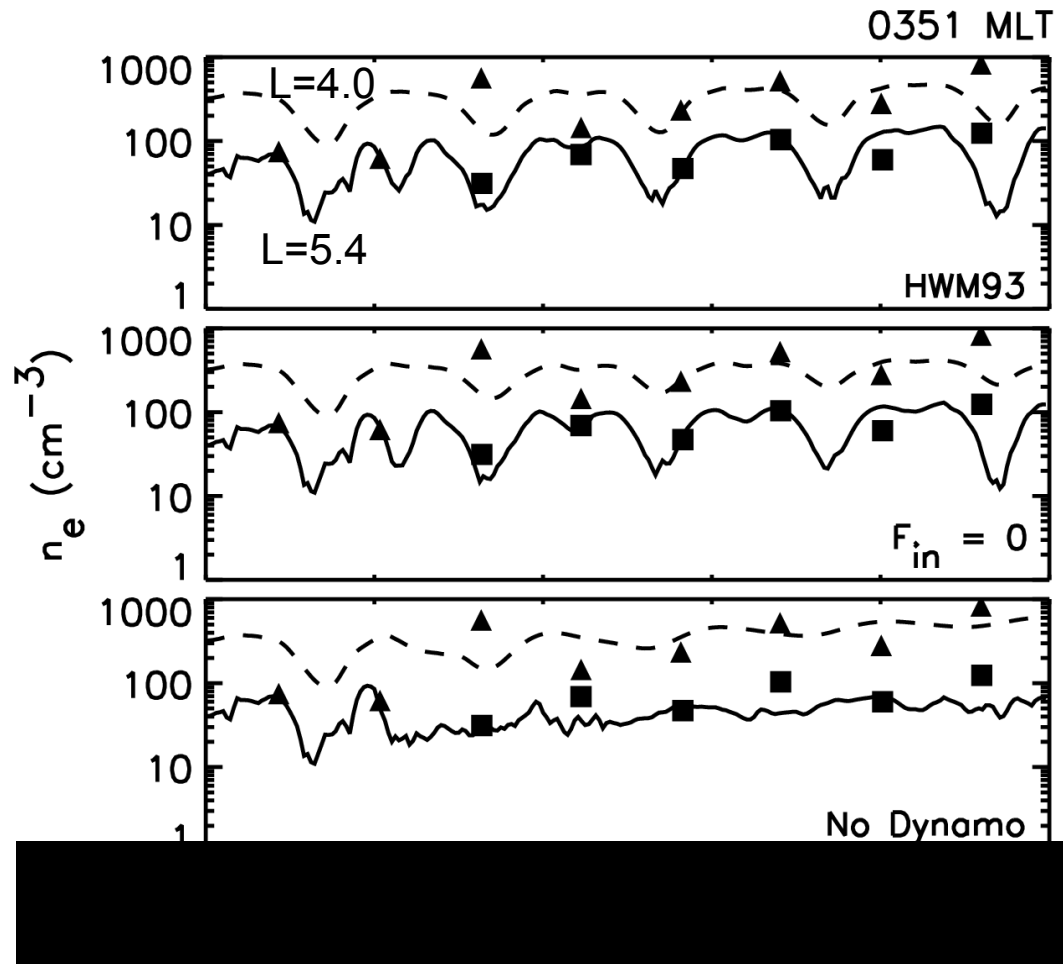
Electron density vs. time
at fixed L, MLT, MLAT

Results shown for the
no wind case and for
SAMI3/TIMEGCM.

Points come from RPI
(passive mode) on the
IMAGE spacecraft.

No winds \rightarrow no oscillations

2001 Day 32-36: IMAGE RPI electron density

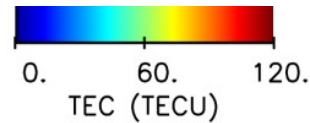


IMAGE/RPI densities
are at MLT 03:50.

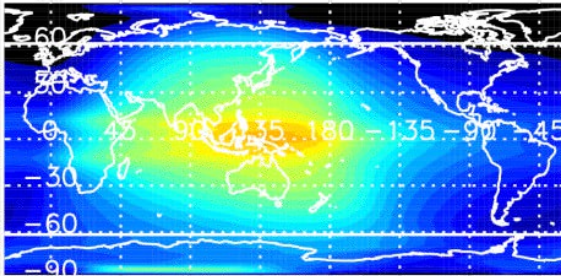
1. SAMI3 with HWM93
2. Without ion-neutral forces, the oscillations persist.
3. Oscillations are gone in the “No Dynamo” case.

2001 Day 32-36: TEC

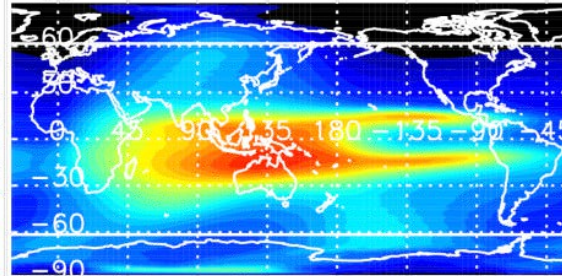
0600 UT Day 36 2001



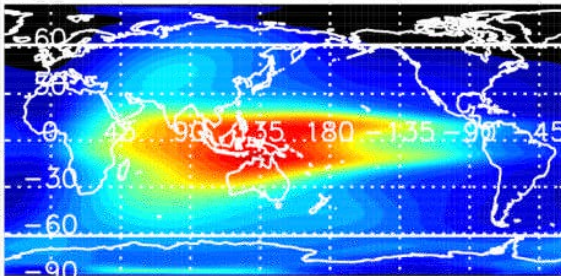
TEC (SAMI3/No Wind)



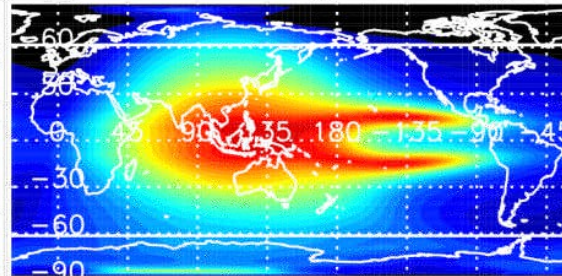
TEC (SAMI3/HWM93)



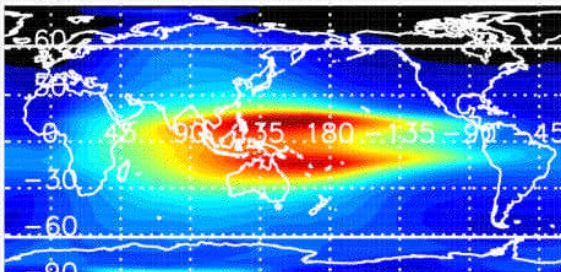
TEC (SAMI3/HWM07)



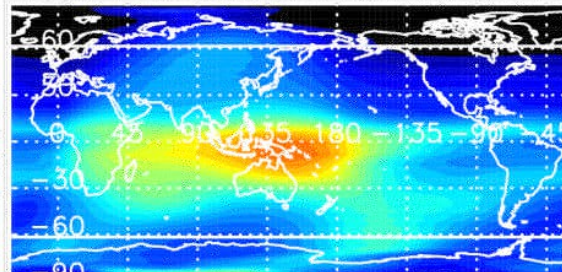
TEC (SAMI3/HWM93, $F_{in}=0$)



TEC (SAMI3/TIMEGCM)



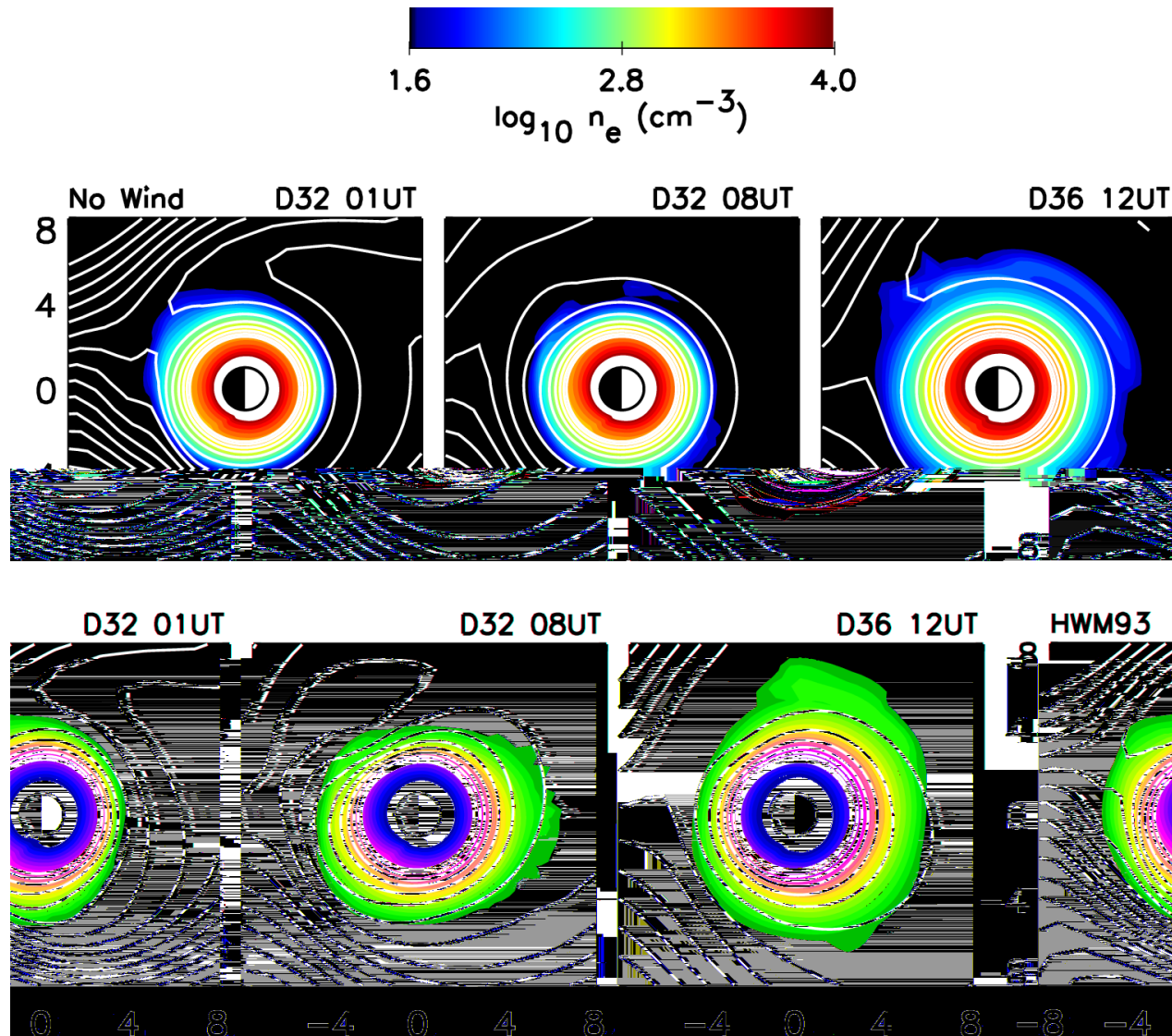
TEC (SAMI3/HWM93, No Dynamo)



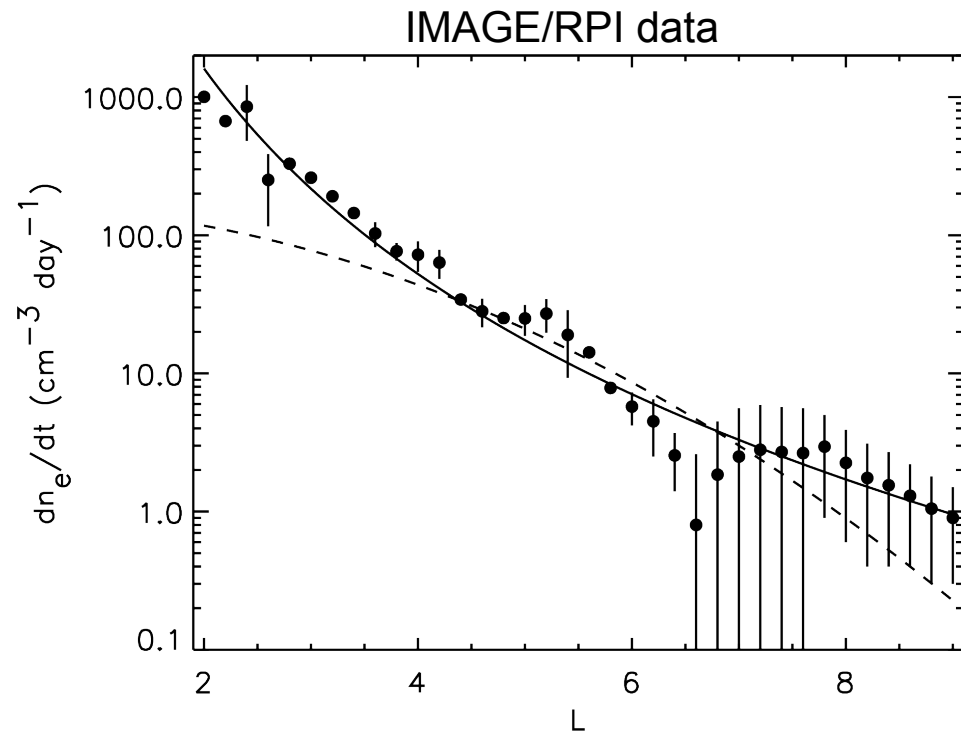
Winds shape the ionosphere as well as the plasmasphere.

Outflow to $3 < L < 7$ is steadier without winds.

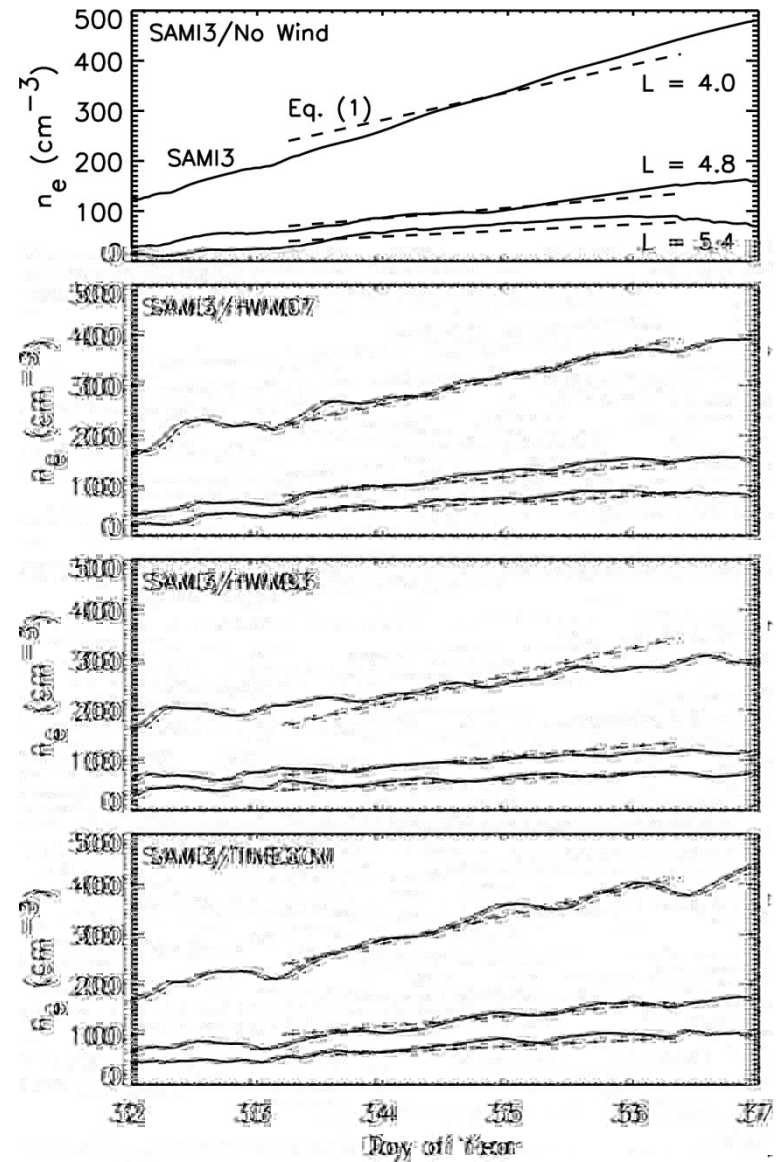
2001 Day 32-36: wind-driven dynamo in quiet conditions



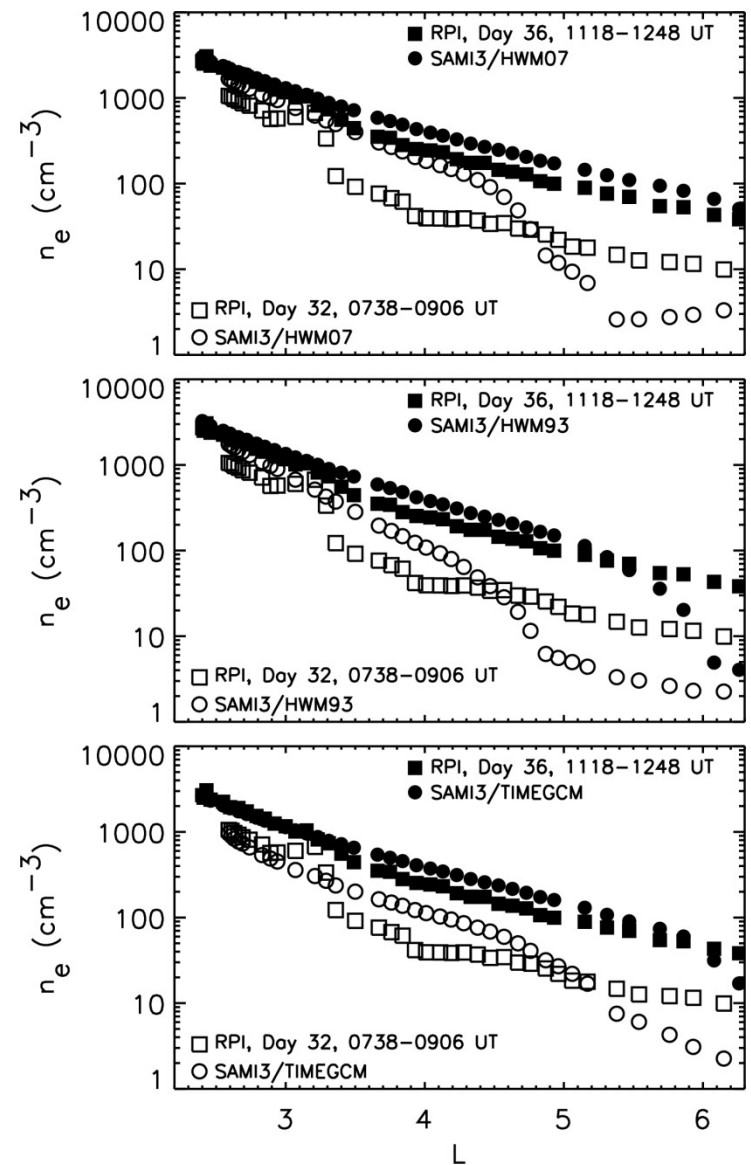
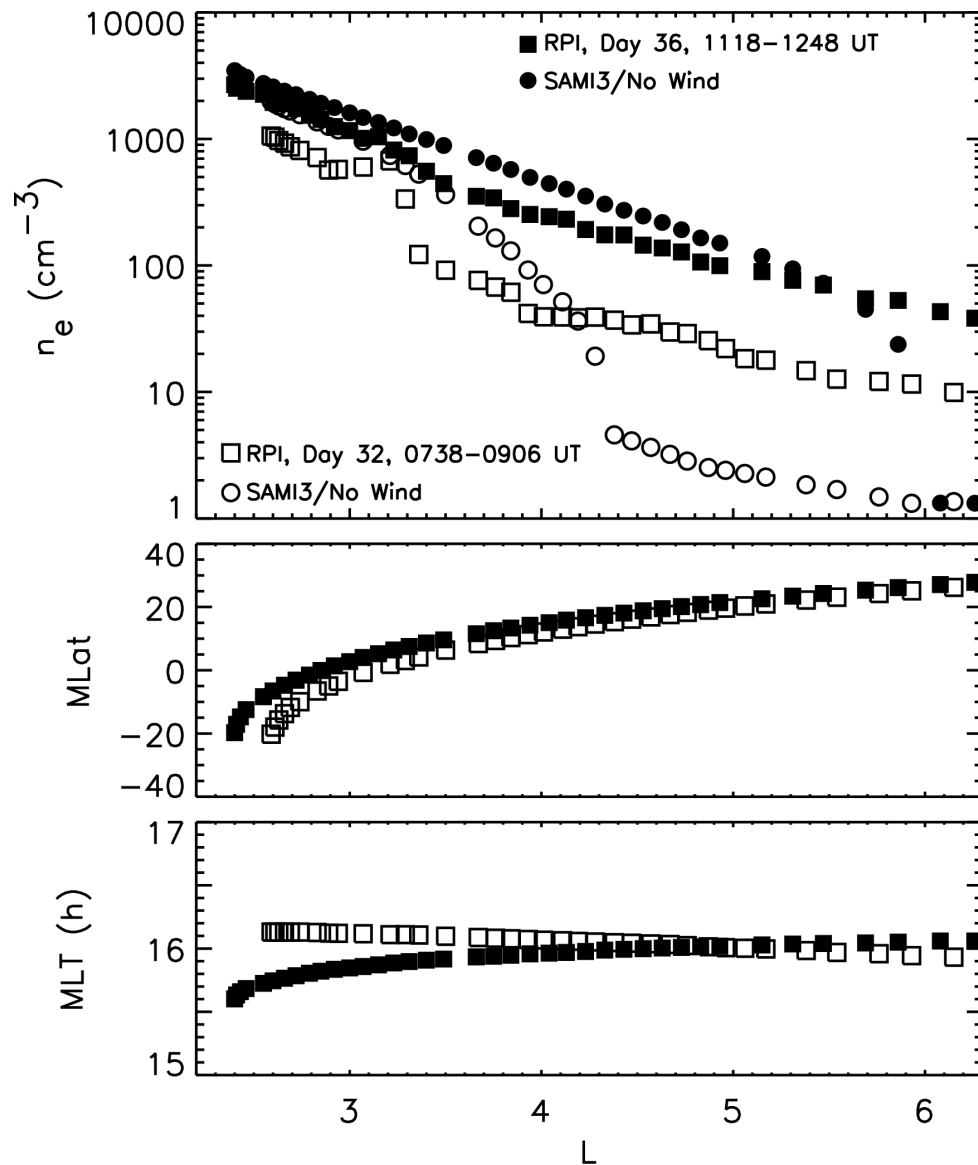
Extra slide: Refilling



$$dn_e/dt = 3.81(6.8/L)^{4.94} \text{ cm}^{-3} \text{ day}^{-1}$$

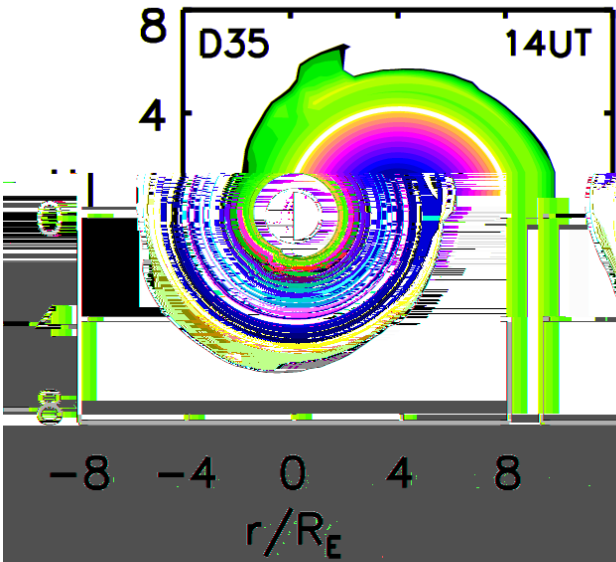


Extra slide: IMAGE/RPI electron density

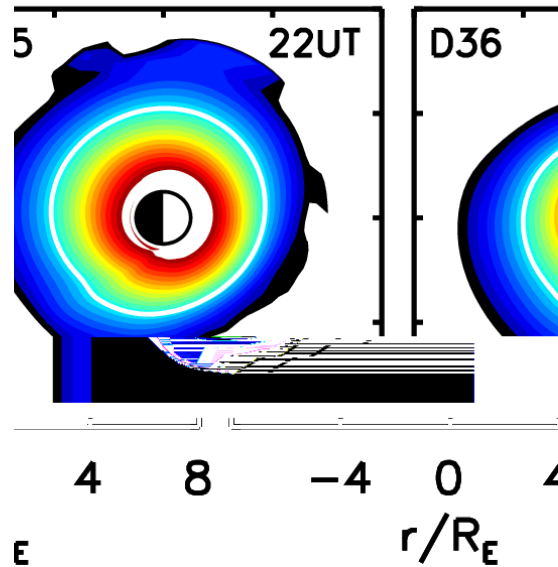


Extra slide: three different wind fields

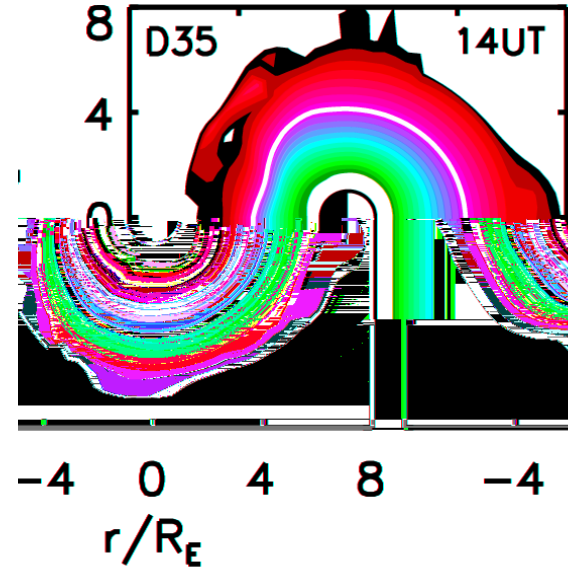
No Winds



HWM93



TIME-GCM



The quiet plasmasphere is affected by the thermosphere.